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THE GRAPE CURCULIO

BY FRED E. BROOKS.

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PLATE 1

Vineyard at French Creek used in the investigation of the damage done by the Grape Curculio in 1905.

THE GRAPE CURCULIO

Craponius inaequalis (Say) LeConte.

Order Coleptera; family Curculionidae.

The grape probably grows about more West Virginia homes than any other fruit except the apple. For this reason any serious injury to the vine or its fruit that may result from the attack of insects is apt to be noticed and deplored by a very large number of our people. This is especially true when the attack is made upon the growing fruit at a time when a good crop seems otherwise assured.

At least two insects are common in this state that feed upon the fruit of the grape. These are the grape-berry moth, *Polychrosis viteana* Clemens, and the grape curculio. The grape-berry moth has been made the subject of special investigation in several states and grape growers are able to combat it intelligently for its habits are well known. The grape curculio, however, so far as the records show, has received but little attention from economic entomologists and the vineyardist who has this pest to contend with can find but little in literature to enlighten him as to its habits and the best means of holding it in check.

For many years frequent complaints have come to the Experiment Station of some insect that "stings" the grapes causing them to become "wormy" and drop from the vines before maturity. In nearly all such cases investigations have shown that the injuries have been due to the grape curculio. In recent years these complaints have become so frequent, and the demand for accurate information along the line of combating the insect, so great, that in the spring of 1905 it was determined to make a thorough study of its distribution, life-history, habits and the possible methods of

as follows to Dr. Hopkins, Entomologist of the Experiment Station:

"I am sending you today some specimens of the grape curculio with two small clusters of grapes, showing the nature and extent of the injury they are doing here

"It seems to me that this insect has not received the attention from writers upon practical entomology which it deserves. It is not mentioned in Farmer's Bulletin, No. 70, of the United States Department of Agriculture, on the insect enemies of the grape, neither can I find it referred to in any of the bulletins of the State Experiment Stations, yet in 1899 it practically destroyed the entire grape crop of both wild and cultivated varieties in Upshur county. In 1900 the injury done was not so serious, yet perhaps one-third of the grapes were destroyed, and this year it is present again in alarming numbers and already my grapes which were not bagged are ruined. Is this insect not generally distributed or how else can I account for so little being said about it?"

The following is copied from Dr. Hopkin's notes of that year:

"August 9, examined grapes near Station building at Morgantown and found that they were badly damaged by the curculio, not one grape in twenty had escaped. Eggs to half grown larvae were found in the grapes. The fact that adults are issuing from the earth in breeding jars where infested grapes were placed on July 16th, indicates that these eggs are of the second generation. August 6, Received Concord grapes from M. A. Becker, St. Joseph, Marshall Co, W. Va., with a statement that the grape crop in that section was ruined."

Early in September, 1905, the following letter was addressed to a few grape growers in every county of the state:

"In many sections of this state, a small, brown beetle known as the grape curculio has done much damage to the grape crop by "stinging" the fruit, causing it to become "wormy." The sting in the grape shows on the surface as a round, dark-colored spot, about one-tenth of an inch in diameter, having a small puncture in the skin near one side. An egg is deposited by the curculio beetle in each puncture which hatches into a whitish grub, or worm, with a brown head. The grub feeds partly upon the pulp and partly upon the seeds of the fruit, causing it to drop before ripening.

"In connection with some experiments now being conducted by this station for the purpose of determining the possibility of preventing, or reducing the damage done by this insect, an investigation is being made of its habits and distribution and your reply to the following questions will be greatly appreciated:

1. Do you know of the occurrence of the grape curcurlio in your locality?
2. If present, what methods, if any, have been used to prevent damage to grapes?
3. How do its ravages compare in extent with those of other grape pests that you may have noticed?
4. Is the insect more, or less, abundant this season than last?

PLATE II.

Photograph made June 30th of four bunches of Concord Grapes from which the bags had just been removed. Bags were replaced on No. 2, and others left uncovered.

Same bunches, thirty days later, with punctured grapes removed from bunches marked No. 1.

5. Approximately, what percentage of your grape crop is usually destroyed by this insect?"

In answer to the letter 112 replies were received. Twenty-eight of these replies stated that the insect was not present, or had not been observed, and 84 reported it present and showed that in at least 43 counties the pest is well recognized. The following abstracts of a few of these letters, selected from widely separated sections of the state, will show the attitude of our grape growers toward this insect.

T. E. Greenbee, Arbuckle, Mason county. The insect you describe is one of the worst enemies of the grape in this locality. I regard it as the prime drawback to grape culture here. Nothing has been done in this county to prevent damage. It is about as abundant this year as last and has destroyed from 35% to 50% of the crop. I sometimes benefit my crop by pruning off unnecessary shoots and part of the leaves. It seems that the insect attacks the fruit that is shaded most. It is the opinion of some that spraying with the right thing would prevent the insect from doing its work. I have sometimes tied small paper bags over the bunches with good success.

E. Meldahl, Parkersburg, Wood County. Yes, indeed, I know of this insect. When it was bad it nearly took the crop. We have used nothing against it. We have not been suffering from it for years as it does not care to attack the Virginia seedling grapes (Nortons). It likes Concord and Catawba and many other sorts but I have very few of them now. I can say that the other grape growers here have not complained of, or perhaps not observed, this insect.

A. B. Ingraham, Waverly, Wood County. We have this insect in our locality. I lost all my grapes from it this year that were on trellises. Those on buildings were not so bad. I have not used anything to prevent damage. It is worse this season than last. Would like very much to find something that would destroy them.

L. E. Villars, Sistersville, Tyler County. The curculio has been here two years. Nothing has been done to destroy it. They are the only insects that trouble grape here and are about as abundant

this year as last. They have destroyed about one-fourth of my grapes. Will be pleased to hear of any remedy you may find for the pest.

J. J. Taylor, Buffalo Lick, Roane County. I know of this insect. They are the worst pest we have by far. Enclosing the grape bunches in paper bags when they are quite small is the only way we can save them. We would be very glad if we could have a remedy. If there is nothing done to prevent them they usually take all the grapes.

Wm. E. Fife, Buffalo, Putnam County. We have had this insect two years. We used lime and sulphur to dust the fruit but it did very little good as the fruit nearly all fell off. It is the worst insect that I have had any experience with. Last year about one-third of the fruit was destroyed, this year about one-half. I have noticed the dark spots on the grapes before but did not know what was causing them until last season.

M. H. Taylor, Masontown, Preston County. Yes, this insect is in this locality. It is the worst grape pest we have. Nine-tenths, at least, of the grapes are usually destroyed. But little careful culture is given to grapes in this locality. What grapes do grow are mainly bagged.

L. C. Williams, Triune, Monongalia County. The curculio is well known here. Nothing to my knowledge has been done to prevent damage. It is the worst grape pest we have and is worse this season than last . Fifty percent of the grapes in this section were destroyed this season. My own crop was a total failure from this cause. The vines were very full early in the season but the fruit all dropped off. I have often wondered if this is the same insect that at times attacks the damson plums. Would like to know of some remedy.

Oliver Gorrell, Algeria, Pleasants County. I suppose this insect is what has caused the trouble with our grapes, as they were stung and fell off as you describe. It is by far the greatest pest we have ever had. We have used nothing to prevent the loss. It is less abundant this season than last. Sometimes it takes all the grapes, this year it took but half. Would be glad to find some method of exterminating this pest.

J. W. Farmer, Triadelphia, Ohio County. Yes, we have this insect. It causes nearly as much loss as all other grape pests combined. The loss seems to be about ten percent. Spraying has been used against it but from inquiries made it seems that it is of only questionable value. Some claim it prevents loss but others think otherwise.

Sam'l. W. M. Peters, Berkeley Springs, Morgan County. Yes, indeed, I know this insect. It is the worst pest of the grape we have except black rot. Have sprayed with Bordeaux mixture. They leave on spraying but return again. It is much more abundant this season than last. I have about two thousand vines and lost my whole crop this year from this insect and the black rot. I find the insect preys on the Worden and Concord but does not seem to trouble the white grapes very much.

W. G. Callaway, Hunters Springs, Monroe County. Yes, we have this insect here. It is the most destructive pest to the grape that I have ever seen. It is worse this year than last and has destroyed about all the grapes in this neighborhood. Nothing has been done to prevent damage.

A. B. White, Man, Logan County. This insect is in this locality. It appears when the grapes are about one-third grown. It is the worst pest of the grape we have and destroys nearly all the crop in this section, except my own. I use F. B. Mill's Moth Catcher and as soon as I think the insects are beginning their work I just set the Moth Catcher near the vines and it does the work. It burns all night.

G. C. Starcher, Berlin, Lewis County. Yes, the grape curculio is very destructive in this locality. Rose bugs do much damage here but the curculio is worse. It is more abundant this season than last and has taken from 50% to 75% of the grapes. While engaged in farmer's institute work I have noticed much damage done by this insect in Ritchie, Doddridge, Gilmer, Calhoun, Lewis, Marion and Monongalia counties. Bagging the fruit and spraying with arsenates have been used to prevent loss.

J. W. McMillion, Rupert, Greenbrier County. Yes, this insect has been here for several years. It is the worst pest that I know of. I think it is more abundant this season than last and to the

best of my judgment has destroyed from 50% to 60% of the grapes. I think the curculio does its work at night as a person hardly ever sees one. Think Bordeaux mixture will prevent much of the damage.

Jno. M. Gribble, West Union, Doddridge County, Yes, the grapes here have been almost totally destroyed for two or three years, and from what I have noticed you describe correctly the way the grapes are effected. The insect is the most fatal to the grape of anything known here and is on the increase as to its ravages. From 50 per cent to 75 per cent of the grapes are destroyed. I have quite a lot of vines on high land facing east and south. I get but few grapes from these vines. They do well until the spots appear, then soon rot and fall off. The only remedy used is to place paper bags over the growing fruit."

Many other reports of a similar nature might be included in this list, but these are sufficient to show that this curculio is found generally over the state and that it is looked upon by grape growers as one of their most dangerous enemies.

In some cases it is apparent that my correspondents have mistaken the work of the grape-berry moth for that of the curculio, but such mistakes are obviously few, and as a whole the reports indicate that the growers have a clear knowledge of the nature of the injury done by this insect and their statements may be relied upon as being accurate.

A few localities of the state seem to have escaped this insect. In September, 1905, I made a somewhat extensive examination of grape vines at Romney, Hampshire county, and near Martinsburg, Berkeley county, and could find no evidence on either the foliage or the fruit that it had ever been present. Reports from correspondents also indicate that it has done but little damage in the other extreme eastern counties of the state and the same is true of several points along the Ohio River.

The conditions that fix the limits of this insect's range, and make it one of the most local in occurrence of all the commoner members of its tribe, are not known. All observations seem to show that it has been on the increase during the past ten years, and whether it will extend its depredations to these small areas

that have so far escaped, remains to be seen. I have found the insect attacking grapes growing under varying conditons from the low lands about Huntington to the high, wilderness parts of Webster and Nicholas counties and no barrier is visible that would seem to prevent it from ranging at will to every corner of the state.

CHARACTERISTICS OF THE INSECT AND ITS WORK.

The grape curculio belongs to that group of insects known as "snout-beetles." The members of this group have the front part of the head prolonged into a slender snout which in some cases is of greater length than the rest of the body. The mouth is situated on the end of this snout and the female uses the apparatus for puncturing holes in fruit, nuts or other plant growth, for the reception of her eggs. The well-known plum curculio and nut weevils belong to this group.

The life-cycle of the grape curculio, as with all insects of this class, is divided into four distinct stages; the egg, the larva or worm-like stage, the pupa or chrysalis stage and the adult or beetle stage. The larval and adult stages are the ones most familiar to grape growers.

The adult, a small, brown, inconspicuous beetle, appears upon grape vines in the month of May, and individuals can usually be found upon the vines, often sitting motionless upon the upper surface of the leaves, on any warm day thereafter until cold weather drives them into winter quarters. Late in June the beetles begin to lay eggs in the grapes. In the process of egg-laying a small puncture is made with the snout through the skin of the fruit and a cavity nearly one-tenth of an inch in diameter is eaten from the pulp beneath. This cavity shows on the outer surface of the grape as a circular, brownish spot with the puncture a little to one side of the center. When the eggs are laid in dark colored varieties like Concord or Isabella, especially when the fruit is nearing full size, the wound may become surrounded by a purplish area, or the whole grape may color prematurely. Often the discovery of these spots will be

the first intimation that the grower will have of the presence of these insects in his vineyard.

The single egg laid in the cavity hatches in a few days into a whitish larva with a small, brown head. The larva spends about two weeks feeding on the pulp and seeds and then, being full-grown, leaves the grape to construct its cocoon on, or just beneath, the surface of the ground. Contrary to a popular belief the infested grapes are no more subject to rot than the uninfested ones, but they usually drop from the vine before the larva leaves them. In cases where the egg or larva die in the course of development the grape does not drop but a hard core, or knot, forms where the cavity was made, which renders the fruit unfit for use.

LIFE HISTORY IN DETAIL.

THE EGG.

The egg of the grape curculio is oblong, eliptical in shape, .22 inch long and .15 inch wide. When fresh laid it is clear white but changes to a yellowish color before hatching.

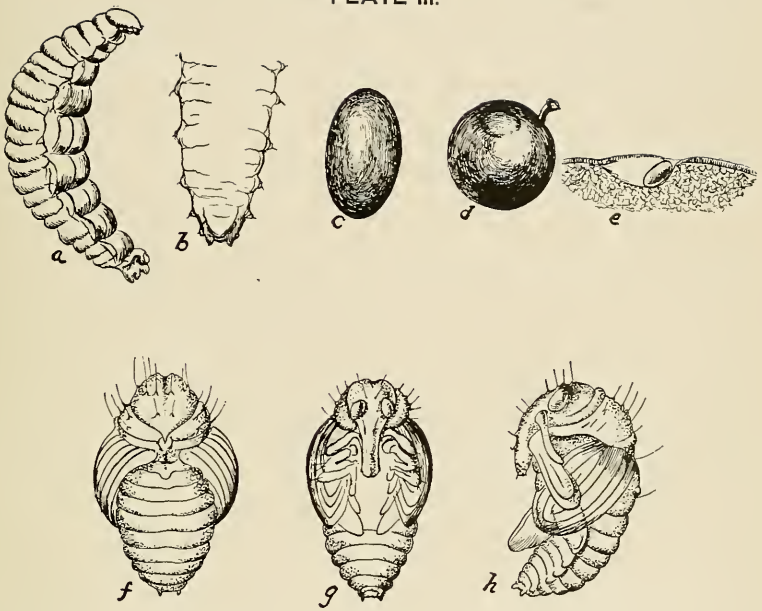
TIME REQUIRED FOR THE EGG TO HATCH.

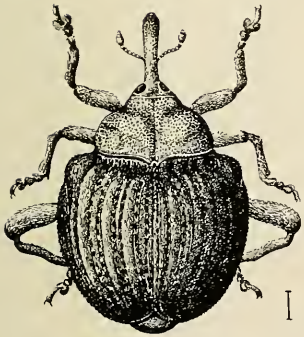
The period of incubation was found to vary in length greatly. The time was observed to the hour in twelve cases and ranged from 109 hours, or 4 days and 13 hours, to 166 hours, or 6 days and 22 hours. The minimum period was for an egg laid on July 15th and the maximum for an egg laid on July 20th. The average length of the period for the twelve eggs was 149 hours, or 6 days and 5 hours. Warm weather accelerates and cool weather retards the hatching of the eggs. In the two extreme cases the average temperature at 7 a. m. for the days of the minimum period was 65 degrees and for the maximum 60 degrees, or a daily difference of 5 degrees cooler for the longer period.

FAILURE OF EGGS TO HATCH.

Practically all of the eggs that were laid and kept in the laboratory hatched, but of those laid in the grapes on the vines,

PLATE III.





I.

J.

K.

THE GRAPE CURCULIO.—a, larva; b, posterior extremity of larva, ventral surface; c, egg; d grape showing puncture; e, position of egg in grape: f, g, h, different views of pupa; I, adult curculio. All much enlarged. Drawings by Hopkins and Strauss. J, K, Curculios in act of egg laying. Natural size.

the large percentage of failures was rather remarkable. Some of these failures were probably due to the attacks of egg parasites, though none were reared. In one case a minute coleopterous larva was found devouring an egg. Failure to hatch of eggs laid in grapes that were exposed to the bright sunlight was very noticeable. Many other failures could not be accounted for. On July 24th, 330 punctured grapes were examined that had been collected from the vines seven days before. 144, or 43.7 per cent of these contained living larvae or the holes in the skins through which the full grown larvae had escaped. In the other 186, or 56.3 per cent, the eggs or larvae had succumbed to causes that in most cases were obscure.

These observations apply only to the eggs of beetles that have lived over winter. The eggs of the young beetles were largely infertile. Under the same laboratory conditons that proved favorable to the hatching of the eggs of the first brood, only 2 out of 160 eggs of the second brood gave larvae.

LARVA.

The larva of the grape curculio is a small, elongate, legless grub, white with a light brown head. The following discription is from Dr. Hopkins:

"*Matured larva*: length 7 mm., width at head 1 mm., at the last abdominal segment 1 mm., at the middle 2 mm., body with 11 segments, head and thoracic segments small, front of head with 7 short erect hair, middle segments much stouter becoming smaller towards anterior and posterior extremities, body thickly clothed with very fine short hairs, prothoracic segments without legs but with obscure leg scars, last abdominal segment with four prominent projections from the anterior margin. Described from one alcohol specimen."

HABITS OF LARVA.

The young larva begins to feed upon the grape before it is free from the shell. The first two days of its life are spent in eating tortuous tunnels through the fruit. The third day the seed is usually attacked and on the fourth day it will often be found in the center of the seed, having eaten entirely through the hard outer covering. When full

grown it eats a small hole through the skin and with great exertion squeezes itself through and quits the grape. Upon leaving the fruit the larva becomes exposed to the attack of ants and other enemies and makes haste to find a suitable place for the construction of its cocoon. For this purpose it seeks a fissure in the ground, or a lump of earth, a stone or fallen leaf, beneath which it may crawl, in its awkward fashion, for protection. If no such object is immediately at hand it will construct its earthen cocoon on the surface of the ground, without protection of any kind, or sometimes, in loose earth, will work its way just beneath the surface of the ground, but rarely, if ever, to a greater depth than half an inch, except where there is some sort of a channel for it to follow.

The exit from the grape is usually made in the early morning. Fully 90 per cent of the larvae were found to leave the grape between day-break and 8 a. m. In this respect it is unlike the larva of the plum curculio, which was found by Professor Crandall of Illinois to leave the fruit without reference to the time of day.

The period from the deposition of the eggs to the emergence of the larvae from the grape was found to range from 13 to 22 days. The following table shows the number of days spent in the grape, as egg and larva, by 997 individuals in the laboratory and 170 in the field:

TABLE SHOWING NUMBER OF DAYS FROM DEPOSITION OF EGG TO EMERGENCE OF LARVA.

RECORD FROM EGGS LAID JUNE 21ST, TO JULY 12TH.

No. of days	13	14	15	16	17	18	19	20	21	22	Total.	Average No. Days.
No. larvae in laboratory	4	66	266	299	177	138	32	12	3		997	16.2
No. larvae in field			2	11	27	58	39	25	7	1	170	18.3

It will be seen that the period for the laboratory was 16.2 days and for the field 18.3 days. The difference of two days was no doubt due to the somewhat warmer and more equal

temperature of the laboratory. Under normal conditions the time spent by the curculio in the grape may be given as 18 days, 6 days as an egg and 12 days as a larva. The period increasing or decreasing slightly according to whether the weather is cool or warm.

A date record was kept of the emergence of nearly 8000 larvae. The first left the grape on the morning of July 7th, and a few stragglers continued to emerge up to the last of September. Of the total number 44.9 per cent emerged in July and 51.7 per cent in August.

THE PUPA.

Hopkins describes the pupa as follows:

Short, stout, yellowish with reddish eyes, head with several (4) acute tubercles each bearing a long curved brown hair, rostrum with four small hairs near the base and two small pilated tubercles near the middle; prothorax with numerous acute piliated tubercles, metanotum with one tubercle on each side, abdomen without tubercle or hairs but with two recumbent cordal spines; the antenal pate extends parallel with front leg to middle of femora, front and middle leg pates broad, flat, grooved, the front shorter but over-lapping the middle one, the third hidden by the wing pate except a small part which projects above the elytral pate; each leg bears a stout hair at base of tibia, elytral pate short, deeply grooved and extends to the posterior edge of hind leg; under wing extends beyond elytra but the apex of the body rather widely separated. Described from one fresh living specimen, 7737a.

PLACE OF PUPATION.

As has been stated, the larva on leaving the grape immediately looks for a suitable place for the construction of a cocoon in which to pass its pupal stage. The place chosen may be under any convenient stone or lump of earth, or the larva may work its way just beneath the surface of the ground, or very frequently the cocoon may be made directly upon the surface of the ground without protection or covering.

For several weeks I kept a basket filled with infested grapes suspended in a shady place so that the larvae on emerging would drop through the openings in the bottom of the basket onto a bed of fine earth. On August 17th, I made a thorough examination of this bed of earth and found 240 cocoons. Twenty

were under a small stone that lay within a foot of where the larvae dropped, 164 were on the surface of the ground, 51 were within a fourth-inch of the surface and 5 were between a fourth-inch and half-inch below the surface. None were found on this or any other occasion at a greater depth than half an inch.

PERIOD OF PUPATION.

The length of time spent by the insect in the cocoon was determined in 365 cases. Three beetles appeared 13 days after the larvae left the grape, one remained in the cocoon 23 days, but the greatest number (180) left the cocoon on the 19th day. The average period for all was 18.6 days, a period corresponding almost exactly with that spent in the grape by the egg and larva. The following tabulation shows the number of beetles to emerge each day between the two extremes of 13 days and 23 days.

TABLE SHOWING PUPAL PERIOD.

No. of days	13	14	15	16	17	18	19	20	21	22	23	Total.
No. of Beetles	3	1	17	29	27	29	180	61	10	7	1	365

TIME REQUIRED FOR DEVELOPMENT FROM EGG TO BEETLE.

The time required for the complete transformation of the insect from the laying of the egg to the emergence of the mature beetle was determined in a separate lot of 247 individuals. Two beetles left the cocoon in 32 days after the laying of the egg and one required 41 days. The average time for the lot was 35.2 days.

THE BEETLE.

APPEARANCE AND HABITS.

The mature grape curculio is a small, inconspicuous beetle of robust build. The female, exclusive of her snout, is a little over one-tenth of in inch in length and the male slightly smaller. When the beetle first emerges from the cocoon its color is black with a grayish tint given by the sparce covering of minute, white hairs.

In a few days the black ground-color fades to brown. This change of color has led in some cases to confusion as to the identity of the beetle, for it has been described by some writers as black and by others as brown. Walsh, (Report on Insects of Ill., 1867,) who evidently described from freshly emerged, black specimens, can not reconcile his observations with the description written by Say, which says the beetles are brown. He refers to these conflicting descriptions as

"An entomological riddle, to solve which, would certainly require a guessing machine of 1,000 Yankee power."

The beetle, even when abundant, is difficult to see. It can most readily be found in the act of feeding upon the upper surface of the grape leaves, but even in this position it is scarcely distinguishable from a small lump of clay. When disturbed it will jump like a flea and fall to the ground or fly away. On being captured and held between the thumb and finger, or otherwise closely confined, it will emit a shrill squeaking sound which serves as a good means of identification.

FOOD AND FEEDING HABITS.

The grape probably furnishes the entire bill-of-fare for the grape curculio. So far as I can learn, there is no record of its attacking any other plant. I have forced beetles in confinement to feed upon leaves of apple and cherry and in one instance coaxed a female to lay an egg in the customary manner in a berry of the Virginia Creeper, *Ampelopsis quinquefolia.* The egg hatched and the larva fed on the berry but died at the end of two days. Under natural conditions I have never seen the feeding marks of the beetles on any leaves nor known the female to oviposit in any fruit other than those of the grape.

As has been previously recorded, the larva spends from 12 to 15 days in feeding upon the pulp and seeds of the fruit, and to this habit alone is due the injurious nature of the insect. The beetle, a few hours after leaving the cocoon, begins to feed upon other parts of the plant and continues to feed with considerable avidity throughout the entire active periods of its life. Its principal source of food is the green, upper layer, or epidermis, of the

leaf. This, it varies occasionally with the bark of the fruit stems and, in the case of the female, with that part of the skin and pulp of the fruit which is removed in excivating her egg chamber. The feeding mark made by the beetle on the leaf is conspicuous and characteristic and can be used, while grape vines are in foliage, for determining the presence of the insect in any locality. The mark, when first made, is light green in color but changes to whitish in a few days. It may be a single line, one twenty-fifth of an inch wide and from one-eighth to one-sixth of an inch long, or more frequently, two or more such lines lying parallel and often so close together as to appear a plane spot. A close examination, however, will reveal the ridges separating the lines and also the minute transverse marks made by the jaws in scraping. In the fall, after the young beetles have appeared, these marks on the leaves often become very numerous. I have sometimes seen, late in the fall, grape vines with their entire foliage presenting a scorched appearance from the great number of these feeding marks. It can not be supposed that the marks are to any appreciable extent injurious to the vines but they are of interest because they at once suggest to the vineyardist an effective and practicable means of destroying the insects.

In vineyards where the insects are numerous almost every cluster of fruit will show on the stems a few small, ragged marks where the beetles have gnawed the bark but these marks are usually so few as to be unimportant.

The beetles rarely, if ever, attack the fruit for the purpose of feeding only, and it will be seen by those who are acquainted with this insect's near relative, the plum curculio, that the feeding habits of the two species are unlike in several important particulars.

THE YOUNG BEETLES IN THE FALL.

The first young beetles seen in 1905, were three that appeared in breeding jars on July 20th. These were soon followed by others and in a few days a great many could be found upon the vines associating with the parent insects. The young beetles were very active and began feeding upon the leaves within a few hours after their emergence. A large number were

PLATE IV.

Half bushel of "wormy" grapes.

A

B

A, Cocoons of curculio.

B, group of curculio larvae. Natural size.

kept in confinement and on August 6th several pairs were observed to be mating and on August 7th an egg was found in a bunch of grapes that had been placed with them for the purpose. When it was found that the young beetles were going to produce eggs the first season, eight pairs were immediately confined separately in jelly glasses where they were supplied with fresh grapes and leaves every morning for 48 days. Two of the females thus confined laid no eggs The six others laid in numbers ranging from 1 to 71. No eggs were laid by the young beetles after August 31st, although the old beetles continued to lay for ten days later. So far as could be observed, no eggs were laid by the young beetles which appeared after the first of August. Only two of the 160 eggs laid by these eight young females hatched. Of these one remained in the grape, as egg and larve, for 19 days and died in the larval condition after leaving the grape. The other remained in the grape 20 days and then entered the ground and constructed a cocoon but died soon after.

Although a second brood of eggs is produced, it seems probable, from the large percentage of infertile eggs and the weak condition of the few larvae that result from those that are fertile, that, in West Virginia, mature insects of the second brood are extremely rare. Farther south there may be a second brood of some importance.

On warm days during the summer and fall the young beetles are almost constantly on the leaves feeding. This is continued until cool weather drives them into winter quarters. A few tardy individuals undoubtedly remain in the cocoon over winter and issue in the spring at about the time the others are emerging from hibernation.

THE BEETLES IN THE SPRING.

In the spring the beetles emerge from hibernation at about the time grapes are in bloom. In 1904 the first was seen on June 1st. In 1905 two were found feeding on grape leaves on May 25th. From the appearance of the feeding marks on one of these leaves it was evident that the beetle had been out for two or three days. Upon their first appearance the beetles seem sluggish and move

about but little. One freshly emerged beetle was observed to spend the days upon the upper side and the nights upon the under side of a single leaf for nearly a week. Gradually they become more active, but usually confine themselves to one vine, or clump of vines, for several weeks. They thus remain feeding in an exposed manner until such grapes as Concord are one-fourth grown. In 1905 this period from emergence from hibernation to the beginning of egg laying covered about 25 days. Mating and egg-laying begins about June 15th to 20th, and continues until grapes are ripe.

The young beetles appearing late in July cause the two broods to overlap from that time on. At first the darker color of the young beetles makes it easy to distinguish between the two, but the dark color soon fades and afterward the old and young can not be separated. The data relative to the period of activity of the old beetles after the appearance of the young brood was, therefore, mostly obtained from specimens in confinement.

WHERE THE INSECT PASSES THE WINTER.

In 1891, F. M. Webster, writing in Insect Life, refers to a case where two grape curculios were said to have been found in the winter in siftings of earth taken from a vineyard in the mountains of Arkansas. In reference to the hibernating quarters of the insect he says:

> "I believe it to be the fact that the grape curculio passes the winter closely ensconced in the ground about the bases of the grape vines or under the loose flat stones with which the surface of these mountains is thickly strewn."

All efforts that I have made to find the beetles in the winter have been unsuccessful except in the case of a few that emerged in mid-winter from cocoons which were supposed to be empty and had been taken by chance into a warm room, and also with a number that were placed in a cage late in the fall. The cage was partly filled with lumps of earth, chips, and rubbish and placed in a cool shed where is was exposed to all the changes of the weather. On the first of January the contents of the cage were examined and the live beetles were found adhering to the under sides of the pieces of rubbish and lumps of earth. None

were found burrowed in the earth except where the coarse material furnished openings for them to follow.

HOW THE EGGS ARE DEPOSITED

As has been stated in other chapters of this bulletin, there are two seasons of egg laying with each annual brood of the curculios. The first is that of the young beetles, soon after their emergence, and in the cases observed began and ended in the month of August, the period covering but 21 days. The egg laying of this period was engaged in by only a part of the earlier arrivals of the brood, most of the young beetles reserving their eggs until the following season. After hibernating over winter the beetles begin to lay eggs again about the middle of June and a few individuals continue to produce eggs until September. This is the period of chief importance to the grape grower.

The process of egg laying was observed many times in detail and is a painstaking operation on the part of the insect and an interesting study for the observer. The insect is not easily disturbed while engaged in the act, and by exercising a little care I could remove a grape, upon which a female was beginning to work, from the cluster and by holding it between my fingers could watch every movement through a hand lense. The first step in the operation is a careful examination which the beetle makes of the grape by crawling about with the tip of her snout pressed against the skin. Just what position she seeks in this examination I was never able to determine for no particular point of the grape surface seems to be selected oftener than another, and the point chosen would always appear exactly like any other on the grape, in so far as any advantages that I could see were concerned. The point being selected the beetle fixes her feet firmly and by straightening her legs elevates her body so as to bring all the pressure possible to bear upon the snout, the point of which is pressed against the skin of the grape. She then begins a see-saw motion of the entire body, accompanied by a rapid working of the minute jaws, which forces an opening in the skin. With thin skinned and young grapes this part of the

operation is of short duration, but with tough skinned fruit it sometimes requires several minutes to make an opening. The skin being pierced the beetle with a chiseling motion of the snout excavates an egg chamber beneath about .07 inch deep, .09 inch long and .07 inch wide, the puncture in the skin measuring slightly under .02 inch in diameter. The pulp removed in making the cavity is eaten by the beetle.

When the excavation is completed the beetle withdraws her snout and turning about presses the tip of her abdomen to the hole. After remaining in this position from one to three minutes she lifts her body slightly and deposits a small mass of excrement which covers the puncture in the skin and seals the egg chamber. The beetle then crawls away without turning to examine the completed work, the whole operation lasting about 20 minutes.

Upon opening the chamber the egg was always found attached to the wall at a point farthest from the opening in the skin, and as no evipositor was visible, I could not at first determine how the egg was placed in position. I found, however, that by taking advantage of the exact moment when the beetle had withdrawn her snout from the puncture and was turning to apply her abdomen, I could cut away a section of the grape so as to open the egg chamber from the lower end, and then by applying my lense to the opening I could watch the procedure from the inside. As the movements of the beetle in turning are somewhat deliberate, I was able by working rapidly to make the incision and have my lense focused on the spot at the instant the beetle was in position to lay the egg. Almost immediately after the point of the abdomen appeared at the hole an ovipositor, corresponding closely in size and shape to the snout of the beetle, would be thrust in and moved about as though to make sure that no mistake had been made as to the proper position. The ovipositor would then be withdrawn and no movement would be visible for several seconds. Then suddenly the ovipositor would be thrust out in a rigid line, deflecting forward so as to form an acute angle with the ventral line of the body. At the same instant the egg could be detected moving rapidly down the ovi-

duct from which it would be ejected against the wall of the chamber.

Many departures and variations from the customary course of procedure in egg laying were noticed. Two egg cavities were found which co: tained two eggs each, several cavities containing eggs were found in the stems of the grapes, and eggs were not infrequently found upon the surface of the grapes. Several females showed a decided tendency to shirk their work by laying eggs in this way. This habit was especially noticeable with the young beetles in their first attempts at egg laying. One such beetle, still unpracticed in the art, was observed to make an egg cavity and then deposit her egg on the surface of the grape near to the puncture. Evidently not being satisfied with the result she turned to examine repeatedly with her snout, first the cavity and then the egg. She made no attempt to move the egg and finally left, evidently well aware that the job was a failure. This was the first and only instance observed of a beetle turning to examine the cavity after evipositing.

In warm weather the beetles remain active and egg laying continues all night. To ascertain the relative number of eggs laid in the day and night, a record was kept of eight females from July 12th to 22d, a period of ten days. The beetles were confined in a light room from 7 a. m. to 7 p. m., and from 7 p. m. to 7 a. m. were covered so that they were in total darkness during all of the night period. At the expiration of ten days 161 eggs had been laid in the day, and 184 in the night. This indicated that, especially during warm weather, more eggs are laid in the night than in the day.

THE STING AND THE ROT.

Several correspondents in speaking of the injury done by the curculio say that "grapes after being stung will rot and fall from the vine." Repeated and careful examinations, however, indicate that no relation exists between the sting of the curculio and either the "birds-eye rot" or "black-rot" of the grape. On July 10th, when both diseases were very prevalent in the vineyard, I collected 125 grapes having both rotten spots and cur-

culio punctures. Of these grapes only four showed any possibility of the rot having originated at the point of puncture. These rots often spread through a vineyard during the egg laying season of the curculio, but no evidence could be found to indicate that the insects had any part in the dissemination of the diseases.

NUMBER OF EGGS LAID BY A SINGLE CURCULIO.

For the purpose of determining the amount of damage that a single female curculio is capable of doing, an attempt was made to get a record of individual egg capacity. On June 22d, when it was found that egg laying had begun, thirty pairs of beetles were collected, as fast as they could be found mating, and confined separately in ordinary jelly glasses. The glasses were provided with cheese-cloth covers and kept in the open air much of the time during the day and in a cool room at night. Every effort was made, at all times, to keep the temperature and other conditions about the beetles as nearly as possible to that prevailing in the vineyards. As long as the beetles lived they were every morning supplied with fresh leaves and grapes, and the eggs produced during the previous twenty-four hours counted. In this way a very complete egg record was obtained, which is shown in the following table.

No.	Date of confinement	Date of death	Days under observation	Date of first egg	Date of last egg	Daily range of eggs	No. of eggs	No. of eggs laid on surface	No. of eggs laid in stem	Death of male	No. days on which eggs were laid	No days from first to last egg
1	June 22	Aug. 28	68	June 22	Aug. 24	1-9	221	0	0	Aug. 19	59	64
2	" 22	" 29	69	" 22	" 12	1-11	242	4	0	?	51	52
3	" 22	Sep. 28	99	" 23	" 26	1-8	243	4	0	Sep. 23	59	66
4	" 22	Aug. 13	53	" 22	" 11	1-8	148	3	0	Aug. 12	37	51
5	" 22	Sep. 27	98	" 23	" 27	1-14	392	0	0	Sep. 6	64	67
6	" 22	Aug. 15	55	" 22	" 11	1-8	116	1	0	Aug. 9	42	51
7	" 22	Sep. 28	99	" 22	" 21	1-10	268	0	0	Sep. 28	53	61
8	" 22	" 26	97	" 22	Sep. 9	1-10	272	1	0	" 18	58	80
9	" 22	July 14	23	" 22	July 11	1-6	63	0	0	?	19	20
10	" 22	Aug. 31	71	" 23	Aug. 27	1-8	185	1	3	?	55	66
11	" 22	Sep. 6	77	" 26	" 25	1-10	307	0	0	?	56	61
12	" 23	" 8	78	" 23	" 17	1-11	288	0	6	?	52	56
13	" 23	" 27	97	July 1	" 23	1-8	158	2	0	Aug. 10	43	54
14	" 23	" 29	99	June 23	" 31	1-13	369	0	0	?	65	70
15	" 23	" 17	87	" 23	" 30	1-11	307	1	0	Aug. 24	64	69
16	" 23	" 29	99	" 23	" 22	1-9	217	5	2	July 25	51	61
17	" 23	" 30	100	" 23	" 12	1-14	352	0	0	Aug. 15	50	51
18	" 23	" 30	100	" 23	Sep. 1	1-11	294	0	0	July 29	52	71
19	" 23	Aug. 24	63	" 23	Aug. 17	1-11	289	1	2	?	53	56
20	" 23	" 30	69	" 23	" 25	1-13	340	0	0	?	57	64
21	" 24	Sep. 6	75	" 24	Sep. 5	1-13	314	1	3	?	58	74
22	" 24	Oct. 6	105	" 24	Aug. 10	1-14	314	0	0	Sep. 23	45	48
23	" 24	Aug. 13	51	" 25	" 11	1-13	305	0	0	?	48	48
24	" 24	Oct. 4	103	" 25	" 19	1-9	267	0	0	Sep. 28	52	56
25	" 24	Sep. 26	95	" 25	" 20	1-13	309	0	0	?	53	57
26	" 24	Aug. 24	62	" 25	" 13	1-8	133	1	3	Aug. 14	40	50
27	" 24	Sep. 19	57	" 25	" 14	1-13	265	2	2	?	48	51
28	" 25	" 27	95	" 25	Sep. 10	1-12	359	4	3	?	67	78
29	" 25	Aug. 6	43	" 25	July 25	1-10	168	0	0	?	31	31
30	" 25	" 30	67	" 25	Aug. 25	1-9	219	0	3	?	49	62
							7724	21	27			

The total number of eggs laid by the thirty females was 7724, or an average of 257.46 each. The first egg was laid on June 22d, the last on September 10th and the greatest number on July 10th. The minimum number of eggs produced by an individual was 63 and the maximum 392. The greatest number laid by a beetle in a single day was 14 and this record was made by three. The entire length of the egg laying period was 81 days and one female, No. 8, lacked but one day of covering this period, her first and last eggs being 80 days apart. No. 9, the beetle making the lowest egg record, lived but 23 days, while No. 22 lived 105 days, No. 24, 103 days, and Nos. 17 and 18 100 days each.

It is impossible to know whether any of these beetles had produced eggs the previous season. It is altogether reasonable to suppose, however, that such a beetle as No. 9, which made a record of only 63 eggs, may have been one of the precocious individuals like No. 4. of the following table, which laid 71 eggs the first season.

As has been said, in the chapter on "Young Beetles in the Fall," many of the first beetles to emerge lay eggs soon after their appearance. The following table shows the first-season record for eight such females:

FIRST SEASON EGG RECORD OF EIGHT YOUNG CURCULIOS.

No. of beetles	Date of confinement	Date of first egg	Date of last egg	No. of eggs	Daily range of eggs	No. of eggs laid on skin of grape	Days under observation
1	Aug. 9	Aug. 10	Aug. 20	35	1 to 7	9	48
2	" 9	" 15	" 15	1		0	48
3	" 9			0		0	48
4	" 9	" 12	" 31	71	1 to 9	1	48
5	" 9			0		0	48
6	" 9	" 10	" 14	14	1 to 5	2	48
7	" 9	" 11	" 25	34	1 to 5	13	48
8	" 9	" 11	" 13	5	1 to 2	0	48
				160		25	

PREFERENCE FOR CERTAIN VARIETIES.

Several grape growers with whom I have corresponded have observed that the curculio shows a preference for certain varieties of grapes in which to lay its eggs. Mr. E. Meldahl, an experienced vineyardist of Parkersburg, says: "the insect does not care to attack the Virginia seedling, (Nortons)." John W. Hedrick of Summers County, finds that "some grapes seem to be proof against the insect," and Sam'l. W. M. Peters of Morgan County, says: "I find the insect preys on the Warden and Concord but does not seem to trouble the white grapes very much."

The advantage of being able to plant resistant varieties can readily be appreciated, but my observations, covering a period of several years, indicate that in localities where the insects appear in great numbers, there is little to be hoped for in this direction. That there is a preference, however, for the thin-skinned grapes was proven by the following test.

On the morning of July 8th, thirty pairs of beetles, confined separately in jelly glasses, were supplied each with six Concord and six wild "summer grapes," *V. aestivalis.* During the succeeding twenty-four hours 219 eggs were laid by the thirty females, all of them in the Concords. The following morning fresh grapes were supplied as before and at the end of twenty-four hours four eggs were found in the wild grapes and 221 in the Concords.

This test indicated a very decided preference for the thinner skinned grapes, but on the following day, July 10th, examination was made of many of the wild vines of the same variety in the locality and more than half the fruit was found infested. The entire crop of one small vine was gathered and a count made. The number of fruits was found to be 934 and of this number 582, or 62.3 per cent contained curculio stings. This was at the height of the egg-laying season and beetles in confinement laid more eggs after than before that date.

Counts made at several times during the season, showed that in a vineyard where a large number of varieties were growing under similar conditions, the differences in favor of any parti-

cular variety were so slight as to be hardly worth considering. Late in the season the percentage of fresh punctures in tender grapes like Diamond and Winchell was slightly greater than in such thicker skinned sorts as Niagara, Concord and Campbell.

It should be remembered that these observations were made in a locality where the insect was exceedingly abundant. In localities where it is less abundant more discrimination is doubtless shown for varietal peculiarities.

The fruit of a vine trained on the side of a building will often almost escape injury while that growing near the woods, or in a shady or weedy place will suffer most. This fact sometimes leads to the conclusion that one variety may be more or less subject to attack than another. That this difference is mainly due to location may be shown by reversing the positions of the varieties.

HOW LONG DO THE CURCULIOS LIVE?

This question can not be answered definitely but sufficient data has been gathered to show that the adult life of the grape curculio is longer than that of many insects. In 1904 the first eggs were noticed on June 15th and one beetle of this 1904 brood is known to have lived until October 6th, 1905. This would make a period of 15 months and 21 days covered by the one brood in all its stages. Since the early stages of the insect are known to require but 36 days for their completion, it can safely be stated that from the appearance of the first beetles until the disappearance of the last of the brood, a period of over 14 months will elapse. The life of an individual beetle may never be this long but certainly many of them live for more than a year and feed upon the vines during the ripening season of two successive crops of fruit. As nearly as can be determined from the emergence and death records of the several thousand beetles kept under observation in 1905, the average life of the adult is about 1 year and 19 days, and of all stages of the insect, 1 year, 1 month and 25 days.

PLATE V.

Feeding marks on leaf made by adult curculio.

PROTECTIVE MIMICRY.—1, excrement of sphinx caterpillar; 2, curculios; 3, mummied grapes.

HOW THE BEETLE IS PROTECTED FROM ITS NATURAL ENEMIES.

The grape curculio furnishes a very interesting example of that phenomenon which naturalists are pleased to call "protective mimicry," whereby animals, from their close resemblance to other objects near which they habitually stay, are passed unnoticed by their natural enemies. The grouse, invisible among the dead, forest leaves, and the tree-frog, hidden, though in plain view upon the gray bark of a tree, are familiar examples. As has been pointed out the adult grape curculio has two principal feeding places; the upper surface of the grape leaves and the stems of the fruit clusters. While feeding the beetle's movements are so slight as to be almost imperceptable and as it is thus engaged upon the grape leaf its resemblance is so close in size, shape and color to the pellets of excrement dropped by the several species of large caterpillars which feed on grape foliage, that the difference can scarcely be detected even at very close range. While collecting specimens I have several times found myself in the act of bottling the pellets of excrement under the impression that I was securing curculios.

As the beetle feeds upon the fruit stems and while engaged in egg laying it is protected in a similar way by its resemblance to the little, dried-up grapes that, having failed to develop, adhere to the stems throughout the summer. This is especially true when it is feeding on the small-fruited, wild varities for these usually bear a large number of such mummied grapes. A greater part of the beetle's active life is spent where it is surrounded by these objects which it mimics and the birds, or other animals, in search of insect food no doubt pass by many curculios, mistaking them for inanimate objects.

NATURAL ENEMIES.

The grape curculio has many natural enemies among the insects, and the fact that it is so well protected by its resemblance to other objects, furnishes a suggestion that birds may also prey upon it. Insect enemies attack the egg, larva, pupa and adult

but makes life especially hazardous for the larva at the time it leaves the grape and crawls away in search of a suitable place to construct its cocoon. Good evidence was found that the egg is attacked by at least one species of egg parasite, though no specimens were secured. On July 13th I found a minute coleopterous larva, probably a Coccinellid, that had gained entrance to a curculio egg chamber and was devouring the egg. On July 29th a rove-beetle, of the species *Philonthus brunneus* Grav. was captured under a grape vine with a curculio larva in its jaws. In August a nymph of one of the common "stink-bugs" was seen upon a grape leaf attempting to spear a curculio with its sharp beak. The curculio withstood several attacks and then flew away. Afterward the nymph was placed in a glass jar with several curculios and in a short time was found with one impaled upon its beak. A small four-winged fly, *Bracon mellitor* Say, was often seen in the act of inserting its eggs into the grapes infested with the curculio larvae. The larvae hatching from these eggs attacked and destroyed the curculio larvae and then transformed to adults within the grape. These parasitic larvae were often found attached externally to those of the curculio from which they were sucking the life. Several specimens of a very similar species, *Bracon dorsata* Say, were reared from infested wild grapes. Another small, hymenopterous parasite was quite abundant in August about the ground under grape vines and was often seen ovipositing in the cocoons of the curculio. The larvae from the eggs thus deposited devoured the young curculios and then constructed cocoons of their own within, and completely filling those of the curculio. Many examples of this useful little insect were reared from the curculio cocoons and specimens sent to Washington were examined by Dr. W. H. Ashmead and found to represent a new species. The name *Stiboscopus brooksi* Ashm. was bestowed upon it.

Many of the curculio larvae are destroyed by ants and I have even seen the cocoons torn to pieces and the pupae devoured by these insects. During July, August and September I kept a half-bushel basket, filled with infested grapes, suspended over a bed of fine earth under some grape vines near the woods. The basket

had a perforated bottom and as the larvae emerged from the grapes they dropped to the ground. The bed of earth on which they fell became a favorite resort for at least five different species of ants, all of which were seen attacking the curculio larvae and pupae. These were common ants of the following species: *Camponitus pennsylvanicus, Myrmica punctiventris, Lasius americanus, Cremastogaster lineolata,* and *Solenopsis debilis.*

METHODS OF CONTROL.

In the published accounts of the grape curculio, but little definite information can be found regarding combative measures. Various devices and practices to prevent its ravages have been suggested but there seems to have been no thorough test made, and recorded, as to the efficiency of any of them. The suggestions have been based largely upon the known effect of such measures when used against kindred insects, but while these measures are recognized as those in general use for this class of insects, certain modifications in the methods of using them must usually be counted on for each species dealt with. Among the remedies set forth as being of probable benefit are the following: bagging the fruit, collecting and destroying the beetles by jarring them from the vines onto sheets spread upon the ground, collecting and destroying the infested fruit, cultivating the ground about the vines while the insects are beneath the soil undergoing transformation and various and sometimes contradictory, suggestions in regard to spraying the vines with repellents and poisons.

During the investigations recounted in this bulletin, the question of preventing the injuries done by this insect, was considered of first importance in all the details of the work. The study of the life-history and habits of the insect, and the several forms of experimental work, were engaged in with the hope of answering some of the questions which are being asked in regard to this pest by those who grow grapes.

The proposed remedies recounted above were all given consideration and other lines of experimentation which were suggested during the progress of the work were tested in so far as

they seemed practicable. The results of this phase of the investigation were very satisfactory and may be detailed as follows:

SPRAYING.

The beneficial results of spraying as demonstrated by experiments were somewhat surprising, even after taking into account the fact that the feeding habits of the beetle make it peculiarly susceptable to such treatment.

Beetles confined in the laboratory died quickly when fed with grape leaves which had been sprayed with a weak solution of Paris green. Other arsenical poisons had the same effect and while arsenate of lead was not tested it is likely that on account of its adhesive qualities this material would make a more satisfactory spray for the curculio than Paris green.

The material used for spraying was made of four ounces of Paris green and four pounds of lime mixed with fifty gallons of water. The vines selected for the experiment were a short row of Concords and one of Marthas standing about a rod apart and both within fifty feet of the woods. During the six years that these vines had been bearing, the fruit had never escaped serious injury from the curculio, the two varieties suffering equally, so far as could be judged, in this respect.

On June 13th, the row of Marthas was sprayed thoroughly with Paris green and the Concords left untreated. At the same time thirty bunches of fruit of each variety were selected promiscuously over the vines and marked for future comparisons. The spraying was repeated, just as at first, on June 24th, June 29th and July 10th, four applications being made. The punctured grapes on the marked bunches were collected at intervals of about ten days. The thirty Concord bunches when marked contained 589 grapes. During the season 292, or 49.5%, were punctured. by the curculio and 314 eggs deposited within them. The thirty Martha bunches when marked contained 880 grapes and during the season 11, or a little less than 1.3%, were punctured. Of these 11 punctures in the sprayed grapes, 9 were found on August 9th, twenty-nine days after the last spray was applied. Had one

PLATE VI.

The right size for bagging.

Grapes showing egg punctures made by the beetles.

more spraying been given about July 25th, which would have been entirely practicable since the grapes did not ripen until August 26th, there is every reason to believe that the sprayed fruit would have remained, so far as all practical purposes were concerned, free from punctures. All the fruit on the sprayed vines showed the same freedom from attack, and during the height of the egg laying season scarcely a puncture could be found in the fruit, nor a feeding mark on the leaves of these vines.

At the present time when the spray pump is justly regarded as one of the essential implements of the fruit grower it is a pleasure to record one more on the list of insect pests that can be held in check by spraying. By adding arsenic in some form to Bordeaux mixture and applying it to the vines several times while the grapes are growing, the double purpose may be served of checking the rot and reducing to a minimum the ravages of the curculio.

The habit of the beetles of feeding upon the foliage for several weeks in the spring before egg laying begins, and continuing to feed in the fall after egg laying ceases, affords excellent opportunities for killing them with early and late sprayings. Such sprayings should be given early in June and in the fall after the fruit is gathered.

BAGGING THE CLUSTERS.

The practice of bagging grapes to protect them from insects, as well as fungous troubles, has been followed for years in some sections of the state.

This method of protection can be depended upon to absolutely prevent injury by the curculio, providing the bags are securely placed over the grapes as early as June 1st, to 15th. In the experiments at French Creek 6000 two-pound paper bags, such as are kept by all grocers, were used. The two-pound size was found to be large enough, except for occasional clusters of such varieties as Eaton, Campbell, Worden and Diamond. For these, the three-pound size is sufficient. In placing the bags they were slipped over the clusters and the mouth given a flat fold about the stem where they were securely pinned. Where the work was well done the

bags remained securely in place, without tearing, until the latest varities of grapes had ripened.

The pins for the experiment cost 15c per thousand, the bags 85c per thousand and $1 per thousand was paid for the work of placing them on the bunches. 1000 bunches of fruit were therefore protected at a total cost of $2. The Alabama Experiment Station in 1889 found that "It cost $1 to protect 500 pounds, or 1000 bunches, of grapes." This seems less than the work can be done for in West Virginia, although where undertaken on a large scale the cost can no doubt be reduced to considerably below $2. One woman who was employed for the work, at French Creek, after a little practice, placed 1200 bags in a day.

Comparisons were made of the bagged and unbagged fruit of about twenty-five varities. In every case the bagged fruit showed, in addition to freedom from curculio punctures, a very decided advantage in freedom from rot, a brighter and cleaner appearance and in some varities a much better flavor. In no particular did the bagging seem to injure the fruit of any variety.

This method of protecting grapes may be especially recommended for home vineyards and for commercial growers who supply fancy fruit to a special trade.

COLLECTING AND DESTROYING INFESTED FRUIT.

Many eggs and larvae may be destroyed by collecting the infested fruit from the vines, and ground beneath, and feeding it to hogs or disposing of it in some other way. The puncture marks are conspicuous and the infested grapes can very readily be picked from the bunches or gathered from the ground. It was found that about 18 days are spent in the grape by the egg and larva; the collections should therefore be made about two weeks apart in order to secure the larvæ before any of them have attained full-growth and left the grape. This method of combating the pest aims chiefly at reducing the number of beetles that would develop to attack the crop on the following year.

PLATE VII.

A young Green Mountain grape vine with fruit protected with paper bags.

Same vine with bags removed from ripe fruit.

PLATE VIII.

Thirty bunches of bagged, sprayed and unprotected grapes.

COLLECTING THE BEETLES BY JARRING THE VINES.

Some benefit may be derived from jarring or shaking the vines and catching the beetles as they fall. This is done by spreading sheets on the ground under the vines or by using an umbrella-shaped contrivance something like the catchers used in collecting the plum curculio. The beetles when violently disturbed, especially early in the morning, feign death and drop to the ground like the plum curculio. By taking advantage of this habit they may be captured and destroyed. The usual practice of training vines near to the ground, however, often makes it so difficult to get the sheet or catcher into position that the method becomes impracticable. The jarring should be done early in the morning, or in cool, cloudy weather, at any time during the day.

PROPER PRUNING AND TRAINING.

It was noticed that fewer eggs were laid in grapes growing where they were exposed to the bright sunlight and also that a larger per cent. of such eggs failed to hatch than was the case with those shaded from the sun. The facts suggested at once the advantages to be gained from proper pruning and training, thus avoiding as far as possible, a dense growth of vines.

CULTIVATION OF THE SOIL AS A MEANS OF DESTROYING THE INSECT.

It is a well recognized fact that the cultivation of the soil can be made a very effective means of suppressing many insects that spend a part of their lives beneath the ground. The pupa cells, of such insects as pass this stage in the soil, when broken up can never be rebulit and the helpless insect perishes beneath the ground or is thrown to the surface where it soon succumbs to heat or cold or is devoured by birds or other insects. Careful investigations were made along this line with the hope of demonstrating that cultivation of the vineyard at the proper time might destroy many of the young curculios. It was found however, that aside from the indirect benefits following such a practice, but little good could

be claimed for cultivation so far as actually killing many of the insects was concerned. The curculio, as previously stated, transforms from a larva to an adult beetle within a little earthen cocoon on, or just beneath, the surface of the fround. The silk lining of these cocoons holds the grains of earth together making the walls so rigid that but few are broken by running a cultivator over them. A small number must necessarily be killed however, in this way, and others will be burried so deep that on issuing they will be unable to reach the surface. They can, however, as was found by test, work their way up through four inches of loose earth.

The failure of cultivation to destroy the insects will, of course, in no case, be made an excuse for neglecting this important principle of vineyard management. Cultivation and all other practices that tend to give the vines vigor and make them productive, should be given first consideration in all efforts to suppress the grape curculio, for without vigorous fruitful vines, spraying and bagging can hardly be resorted to with profit by the grape grower.

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